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INNOVATION, DYNAMIC REGIONS AND REGIONAL DYNAMICS

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Innovation, Dynamic Regions and Regional Dynamics

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Abstract

This paper analyses the aspects of spatial economics that deals with innovation, regional specialization and dynamic systems of functional regions and in particular the contributions made by the economist Börje Johansson. The innovation aspect consists of innovation networks, knowledge sources and knowledge sinks, cost and innovation of product characteristics and innovation at the industry and sector level. In the regional specialization part the infrastructure, regional economic milieus, the specialization of regions and specific the specialization in small and large regions, spatial transaction costs, and endogenous specialization are subjects that are being treated. Regional dynamics consists of location dynamics in a system of functional urban regions where different theories are being discussed as the spatial product life cycle theory and filtering-down theory. The last part does also take up lead-lag models.

Keywords: innovation, regional, specialization, dynamic systems, functional regions
JEL codes: O31, O18

1. Introduction

The development of economic theory after World War II has focused on clarifying the necessary and sufficient conditions for the existence of an idealized general equilibrium. Debreu (1956), Arrow and Hahn (1971), and Scarf and Hansen (1973) established these conditions, building on earlier attempts by Cassel (1917) and Wald (1933-34, 1934-35). A key assumption in the formulation and proofs of the existence of a general equilibrium of a competitive economy is a large (or even infinite) number of buyers and sellers (Aumann, 1964), which ensures anonymous markets and the mutual independence of agents. Another assumption is the convexity of preference and production technology sets (Uzawa, 1962). A third assumption is flexible pricing of goods and production factors.

The flexibility of prices is the assumption that economists first called into question. Keynes formulated the most influential early criticism of the realism of assuming flexible prices in his *General Theory of Employment, Interest and Money* (1936). In his macroeconomic analysis, Keynes questioned the downward flexibility of the price of labor services and interest rate (i.e. the price of loan-able funds), implying the possibility of equilibrium without full employment. Later, Uzawa (1976) and Benassy (1976) included such Keynesian macroeconomic fixed-price assumptions in a new general equilibrium theory and proved the existence of an even more general class of equilibrium theorems that does not depend on complete price flexibility.

Frank (1969) formulated the first successful attempt to relax the assumption of a convex production technology set. He proved the existence of a set of prices that can sustain both a structure of production in general equilibrium and increasing returns to scale. Andersson and Marksjö (1972) extended Frank's analysis by assuming continuous increasing returns of the technology sets. In both studies it was shown, that sellers of each good must price-discriminate between consumers in order to sustain a general equilibrium.

One of the core characteristics of Börje Johansson's research is the development of theories and models in which increasing returns to scale are compatible with economic equilibrium. Another characteristic is his questioning of the independence of economic agents. The starting point of his research on the consequences of agent interdependence was his doctoral dissertation defended in 1978; *Contributions to Sequential Analysis of Oligopolistic Competition*. That game theoretic study not only assumes statically interdependent agents as in prisoners' dilemmas and other suboptimal equilibrium games, but also takes into account strategic interactions that are truly dynamic.

Interdependencies among agents take on a deeper significance for applied work when agents are distributed in continuous space or on some discrete network. Such interdependencies were almost completely disregarded by American economists, with only a few exceptions such as Hotelling (1929), Chamberlain (1936), Isard (1956), and Greenhut (1971). In Europe, there is however a separate tradition of focusing on such interdependencies, as is exemplified by von Thünen (1826), Alfred Weber (1929), Launhardt (1872, 1882), Palander (1935), Lösch (1954), Beckmann (1952, 1956), as well as Beckmann and Puu (1985). The role of spatial interdependence in the determination of a spatial general equilibrium with assumptions of convex production technology and preferences has been most thoroughly developed in the contributions by Beckmann, and Beckmann and Puu (op.cit.).

Building on this European theoretical heritage, Börje Johansson has explored spatial and dynamic interdependencies in models where the assumption of convex production technologies is discarded in favor of assumptions of internal and external increasing returns. He has also refocused the modeling of interdependencies toward explicit dynamic economic mechanisms, instead of the simple additions of time subscripts, which is typical of static theories and models.

Börje Johansson superbly follows the theoretical advice formulated by Schumpeter:

"This distinction [between statics and dynamics] is crucial. Statics and dynamics are two totally different areas. Not only do they deal with different problems, but they use different methods and they work with different materials. They are not two chapters in the same theoretical construction – they are two totally different buildings." (Schumpeter, 1908: 182-3)

2. Innovations and innovation networks

Innovation is the fundamental factor behind the development and renewal of firms, markets, regions, and entire economies. According to Schumpeter (1934), an innovation can be a new (i) product, (ii) production technology, (iii) market, (iv) organization, or (v) input. We focus on the first three types of innovation, since they usually constitute the majority of innovations. Similarly to production and economic growth, innovations are always unevenly distributed across countries, regions, as well as across localities within regions.[1] Spatial differences result from the unequal attributes of each location. Consequently, Johansson (1998 a) calls such attributes *location attributes*. For each type of economic activity, one can identify certain combinations of location attributes that support it better than other combinations. Some location attributes are gifts of nature, while others are created by investments in physical and human capital with low spatial

[1] Since people and firms are highly concentrated in space of course we would not expect innovation to be randomly distributed across space. The problem is that we need a priori to formulate a null hypothesis about, what would constitute an "even distribution" (see Ellison & Glaeser, 1997; Duranton & Overman, 2005).

mobility. Still others are the result of the behavior of economic agents with spatial preferences, such as households or firms.

Standard economic theory has devoted little attention to regional differences regarding location, innovation, productivity, and growth. Research with a regional focus has therefore been forced to create its own platform and conventions, which specify relevant and challenging research problems. It is possible to identify a self-organized research program in Sweden, which is based on the work of economists, geographers and other regional scientists since the early 1950s. The inspiration for that research program harks back to the interwar period and the contributions by, in particular, Ohlin (1933) and Palander (1935) (Johansson, 1998 a). One economist and regional scientist who has played a central role in the research program since the 1970's is Börje Johansson. This introductory chapter has as its main purpose to provide an overview of his engagement with - and contributions to - the research field within spatial economics that deals with innovation, regional specialization, and dynamic systems of functional regions.

One way to understand and analyze innovation processes is to study the increased formation of economic networks among producers, subcontractors, and buyers of final products (Johansson, 1990 b; Johansson and Westin, 1994). Such networks consist of nodes and links (Karlsson *et al.*, 2005). Johansson (1991 b) outlines some of the fundamental elements of the emerging theory of economic networks by providing an economic model which explains the creation of linkages and networks, and which also attempts to explain the durability of such relations. The network approach recognizes the importance of repeated mutual investments in the links that connect customers and suppliers (Johansson, 1990 a; Teubal and Zuscovitch, 1994).

Investments in links between suppliers and customers create and expand networks. The amount of investment that is required to establish and strengthen a link between two economic agents is a negative function of the existing affinities between the two nodes and a positive function of the spatial friction. The dominant flows of a specific product or type of information will use links, which have the most appropriate attributes, while at the same time being constrained by barriers and other types of friction.

The links in an economic network must be analyzed as immobile capital goods, which have incurred sizable sunk costs. Existing linkages therefore impose rigidity and inertia on firms' interaction patterns such as trade flows, deliveries of current inputs and capital equipment, and exchanges of technological knowledge. Normally, a link between a supplier and customer will not be broken unless a new supplier can offer a new input, which is clearly superior to the current input, since the new supplier has to overcome the sunk cost advantages of an established link.

Emphasizing the network aspects of the economy, rather than using the traditional price-oriented view of the market, implies that link attributes increase in importance relative to node attributes as explanations of trade patterns, service networks, spatially distributed production networks, and innovation networks. The archetypical model of a market economy with independent actors, in which a quantity of a product is bought from the seller who offers the lowest price at the point of delivery, focuses in a way upon production costs in nodes and, rarely, if at all, on transport and transaction costs. Thus, it disregards the dynamic interplay between market actors, which is not only typical of the market but also shapes its development trajectory.

2.1 Innovation networks

Innovations never occur in splendid isolation. Instead, it is natural to describe product development and renewal of production processes as a natural part of the interaction between a firm and its customers and suppliers through its customer and supplier networks (Johansson, 1993 a). As part of its research and development, a firm also buys R&D results and knowledge support through its network of knowledge channels. The opportunities for an individual firm to improve its production process are dependent upon the conditions for buying new equipment and new knowledge from the suppliers in the firm's supplier network.

Suppliers of new techniques and sellers of new equipment frequently try to use established economic networks as a means to access potential technology customers (Johansson, 1991 b). This is why networks within large corporations often function as arenas for innovation diffusion (Karlsson, 1988). Established networks have two distinct roles. First, the seller of technical systems and production knowledge must supply products, which are either designed specifically for each customer, or which can be adapted to fit the demands of the buyer. Hence, the seller needs existing links as channels through which it is possible to find customers, who also have sufficient purchasing power to pay for the necessary customization. One should emphasize that the customers are, in fact, carrying through their own innovations – although a lot of imitation may be involved. Second, the delivery of new equipment and installation of new systems are processes that frequently take a long time to perform and require frequent interactions between the delivering and receiving firms. Both parties need a reliable link for their co-production, which may include joint development and learning

Firms also receive knowledge about how its products ought to be redesigned trough information from their customer networks. In addition, many firms have specialized knowledge links, which were created to generate better conditions for research and development within the firm. Thus, we can talk about innovation networks as a sub-structure of a firm's general economic network. Of course, the strength of the innovation network varies among firms due to factors such as size, age, and industry.

We may combine the above observations into a model of innovation behavior in economic networks:

1. Established networks for economic interaction are important vehicles for the diffusion of technological solutions. The delivering and receiving parties make contact via direct and indirect links in such networks. The networks therefore facilitate the transmission of knowledge. Networks may play this role regardless of their initial use and rationale.
2. The ability of a firm to improve its production, distribution and other techniques depends on its capacity to build new links to suppliers of knowledge and equipment. Network formation is equally important for a firm that tries to establish cooperative ventures with other firms in order to renew and develop products.

Knowledge plays a critical role in innovation processes. Karlsson and Johansson (2006) argue that it is meaningful to make a distinction between three types of knowledge:

1. *Scientific knowledge* consists of basic scientific principles that can form a basis for the development of technological knowledge.
2. *Technological knowledge* comprises implicit and explicit blueprints in the form of inventions (or technical solutions) that may be transformed into new products or production processes.
3. *Entrepreneurial knowledge* consists of economic knowledge about potentially profitable entities such as products, business concepts, markets, customers, and suppliers.

The different types of knowledge flow from “sources” to “sinks”, using links in different types of knowledge networks.

2.2 Knowledge "sources" and knowledge "sinks"

Links that connect nodes are the conduits for flows in networks. The direction of a flow is always from a "source" to a "sink". If the flow represents an economic transaction, the "source" is a supply node while the "sink" is a demand node. The concepts "source" and "sink" include but are not limited to "supply" and "demand," and are general starting points for analyzing transmissions of knowledge and experiences among individuals, organizations, and over space.

Scientific knowledge is disseminated in open scientific networks with universities and research institutes as permanent "sources" and with courses, conferences and scientific publications as links to the "sinks", which are students and scientists as well as firms that are interested in transforming scientific knowledge into inventions and innovations.

Technological knowledge includes knowledge about production methods as well as technical solutions about the design and construction of goods and services. Technological knowledge usually differs from scientific knowledge in that intellectual property rights in the form of patents and copyrights prevent general use of the knowledge. This implies that new technological knowledge is traded for a price or – if the knowledge-creating firm decides to use it as a strategic resource – is simply unavailable.

As a technology "sink" we can imagine a firm with an intention to start new production or to improve on its current production methods. To make this possible, it needs two types of technological knowledge: (i) knowledge about alternative designs of the planned product, which is the same as knowledge about product outcomes, and (ii) knowledge about available production technologies or processes for producing the product.

There are many “sources” of new technological knowledge. They include the firm’s own experiments, surveys of and contacts with customers, imitation of other firms’ technological knowledge, purchases of patents and licenses, employment of other firms’ employees and new university graduates, as well as in some cases industrial espionage.

Technological knowledge is transmitted from “sources” to “sinks” in three ways: (i) as individuals (human capital), (ii) as books or software (information) (iii) and as equipment (physical capital).

When new technology is embodied in individuals, technology transfer takes place when individuals move from one organization to another or when individuals from different organizations come together in face-to-face meetings. After technological knowledge has “matured,” knowledge workers may codify and transfer it by using drawings, software, and texts or by structured education. When firms buy patents and licenses, they buy codified knowledge. The third form of technology transfer emerges when a firm buys physical capital such as technical equipment or machines, which embody new technological knowledge. It is not unusual for technology transfer to be a complex process, which may involve a combination of hiring individuals which embody critical human capital, training, acquisition of patents, and acquisition of capital goods.

The third type of knowledge – entrepreneurial knowledge – is also critical for innovation processes. It includes knowledge about the demand for products with varying characteristics and the willingness among customers to pay for such products. Entrepreneurial knowledge also includes knowledge about competitors such as their strategies to attract various types of customer. The “sources” of knowledge are customers and competitors, both actual and potential. The links are whatever connects a producer with its customers and competitors, such as information and transport networks.

Inventions and innovations are acts of creation[2] with elusive ultimate causes. It is difficult to go beyond the distinction between inventions and innovations. An invention is the solution to a technical problem. To transform the invention into an innovation it is necessary that the innovator expects the technical solution to be economically viable. Economic viability is determined by production costs (including development costs) and revenue generated from the potential customers. Innovation processes often involve a combination of developing new production methods and new product characteristics. However, there are innovations that only introduce new production methods for producing existing products without any new characteristics, and there are also innovations that only concern the introduction of new product attributes with negligible process innovation.

Maillat, Crevoisier & Lecoq (1993) distinguish between three types of product innovation. The most modest as well as the most common type entails the incremental addition of new elements to an already existing product. In this case, the aim may be to make the product more reliable and versatile. A transformation of the functionality of the product implies a more far-reaching product innovation. Now the product not only fulfills the needs of customers better, it offers new and unexpected functions. Most radical are those innovations that not only create new functions but also new markets.

During the post-war period, many studies have analyzed the innovation intensity of firms by measuring their patent frequency. These studies have been conducted even though there is a general agreement that patents only reflect a small part of all innovations. One question that has interested many economists is the extent to which the market and developments on the demand side stimulate product innovation, and to what extent the internal forces within companies together with the technological conditions for each product group generate new products. A large

[2] The same is true of new scientific knowledge.

study by Scherer (1984) relates patent frequencies to (i) the size of the market for a firm, (ii) differences in technological opportunities for different kinds of goods, and (iii) the renewal readiness of the individual firm. In Scherer's study the market explains a little more than 40 percent, technological opportunities explain about 30 percent, and the individual renewal readiness explains a little more than 10 percent of the variability in patent frequencies.

Energy and skills in knowledge "sources" and knowledge "sinks" govern the diffusion of technological knowledge (Johansson, 1993 a). The diffusion of knowledge and technology does not only depend on the volume and intensity of the flow from the knowledge "source". Technology transfer also results from the demand from the knowledge "sink". The implication is that innovation networks primarily contain links between strong knowledge "sources" and strong knowledge "sinks".

2.3 Cost and innovation of product characteristics

It is common in analyses of innovation and technology diffusion to make a schematic distinction between innovations that focus on improving production techniques (i.e. process innovation) and those that focus on improving existing products or introducing totally new products (i.e. product innovation). Conventionally, process innovation denotes all changes of production techniques that are used in the production of a given product in a given firm. However, the term process need not exclusively imply a narrow conception of technology but may also imply "non-technological" activities in a firm (Fischer & Johansson, 1994). This more inclusive interpretation of "process" corresponds to its use by Nelson and Winter (1982). They argue that a firm embodies a set of interdependent production routines, which combine to form a complex process.

Nelson and Winter's definition implies that a complex production process includes the following sub-processes: (i) distribution, (ii) production, (iii) routine design and construction, and (iv) management, administration and commercial activities. Improvements to any of these sub-processes are process innovations. They primarily refer to changes that lead to more efficient resource use, which, for example, reduce production or distribution costs. In such cases, process innovation equals cost-reducing technical changes. But process innovation also includes those changes in the production processes which increase a product's quality and reduce the proportion of defects, while preserving the original functions of the product.

Process innovations are therefore all innovations that are not product innovations. What is then a product innovation? To answer this question we need a systematic way of describing products. Lancaster (1971) offers one such approach. He suggests a product description, which specifies the various attributes that characterize the product. He calls the attributes "characteristics" and assumes that it is possible to measure the quantity of each such product characteristic. As a consequence, each good or service becomes a specific combination of characteristics. Lancaster's approach is closely related to Schumpeter's analysis of innovation. Schumpeter (1934) treats innovation as the result of a process of new combinations.

When a firm develops a new capital good, we can distinguish between two cases. In the first case, the firm intends to use the good itself and will for that reason attempt to prevent competitors from learning about it. In the second case, the firm will market the new good with the goal of making a profit. The goal is thus to find as many customers as possible with a sufficient willingness to pay for the new capital good with its various attributes. In this case, the firm has made a product innovation. When the buyers of the new capital good start using it in their production process they are making a process innovation.[3]

A need to cut production costs usually causes a firm's efforts to improve its production process. This need is most obvious and persistent for products that are exposed to price competition from rival producers. The impetus to improve the efficiency of the production process recurs every time a competitor has succeeded in improving its production methods, and it also recurs at the onset of each cyclical downturn.

The ability to manage continual improvements to the production process requires a continuous supply of new technology in the form of new technological knowledge. This includes imitating rivals, taking up suggestions from consultants and suppliers, and adapting information that have been gathered through the firm's intra-regional and inter-regional innovation networks.

We should also note that there are interdependencies between product and process innovation. For mature products, there is often a choice between old and new production processes, but new products normally require new production processes.

2.4 Innovation at the industry level

At the industry or sector level, economists study both product and process innovation as entry and exit processes (Johansson, 1987; Johansson and Holmberg, 1982). This approach builds on an important insight in Schumpeter's theory of economic development, which is that the original entrepreneurs receive a premium in the form of greater profits for being pioneers (Schumpeter,

[3] This implies that product innovations in one industry often show up as process innovations in one or several other industries. What is a product or a process innovation depends upon the perspective taken in the analysis. In the case of consumer goods there is normally no need to make this type of distinction.

1934). This “extra profit” to innovators is a temporary monopoly, which results from the specific knowledge that they do not (yet) share with their competitors or only share with a few of them.

Irrespective of whether one assumes that such innovations occur continuously or continually and irrespective of the character of the imitative diffusion process, one should expect an uneven distribution of productivity and profits among the firms in an industry. We should expect pioneering entrepreneurial firms to earn greater profits and have greater productivity than their imitating followers. Empirical data confirm that economic rewards are “Schumpeter-distributed”, and that such distributions have a characteristic form (Johansson and Marksjö, 1984; Johansson and Strömquist, 1981). Moreover, not only does the general form of such reward distributions persist in each industry, but the specific parameters of the distributions exhibit long-term stability.

For innovations among firms in an industry, it is important to observe that innovations appear in two distinct forms: each firm may renew its production technique, but it may also adjust its old technique in order to develop new products. One may use Lancaster’s (1971) approach to analyze the effects of introducing new products. It is possible to combine the substitution of new for old products with the dynamic substitution of new for old production techniques. The dynamic processes of entry and exit generate specific distributions of process and product vintages that are associated with observable profit and productivity distributions. Different assumptions about the entry and exit dynamics generate different forms of the productivity and profit distributions in an industry. Product changes with logistical substitution processes explain the steepness of empirically observed productivity and profit distributions. In the absence of product evolution, technical change generates productivity and profit distributions, which are quite flat.

3. Regional Specialization

In the previous section, we analyzed innovation processes from the perspective of the firm, without considering the fact that innovation processes tend to locate in certain regions, in particular, large urban regions. In this section, we turn to the question of which factors determine the specialization of regions. Before considering these factors, however, we need to consider what a region is.

In a functional economic region, one can identify one or (often) several spatial economic nodes, for example population centers, which physical infrastructure networks and established economic interaction networks jointly connect (Johansson, 1993a). Of special importance are labor market networks, where the links between employees and employers create a tentative structure. Every employment relationship presupposes a contract, which also (indirectly) connects a dwelling to a workplace. A region’s accessibility patterns decide how these contract links generate geographically contiguous labor markets of various sizes.

The links in the labor market constitute one of many networks, which integrate a regional economic system. Another such network is the communication network which job-seekers use to find suitable jobs and employers use to find workers with suitable skills. A functional economic region becomes an integrated economic system through the interaction, which takes place in established networks and includes communication, decision-making, and distribution of goods and services. A functional region has greater mobility of production factors within its interaction borders than with areas outside. Commuting and all other forms of interaction, even within functional regions, give rise to interaction costs. The size of these costs determines the spatial extent of the region.

The heterogeneity of natural conditions and historical development paths means that functional regions differ from one another in their economic milieus, and thus offer dissimilar conditions for economic specialization. The regional economic milieu comprises those location attributes that are durable (fixed or slowly changing), that the individual firm cannot control, that are not traded other than as land attributes, and that influence firms' production activities (Johansson, 1998 a).

3.1 The infrastructure as a set of durable location attributes

A special type of durable location attributes is that part of the built environment in a region that qualifies as material infrastructure. The material infrastructure is durable capital that generates location attributes services, which influence the regional economic milieu (Johansson and Snickars, 1992). It comprises three parts: networks that convey people, goods, and messages; facilities that supply public goods; neighborhoods that provide access to housing and workplaces. Johansson (1991 a) maintains that one may envisage the infrastructure as a landscape of interaction possibilities for resource flows as well as inter-personal and inter-firm contacts.

Infrastructural changes are slow in comparison with the fast adjustments of most social and economic activities, which mean that in the short term the material infrastructure provides an arena for rapidly changing social and economic processes. The material infrastructure supplies services to a collective of users, but the spatial extent of the services is limited. It satisfies at least one of the three following criteria (Johansson and Snickars, 1992): polyvalence; inter-temporal consistency; a systemic or network function that generates accessibility.

It is also possible to identify a non-material regional infrastructure that consists of collective, durable, and relatively immobile location attributes, for example agglomerations of human capital and regional institutions (Andersson, 1985). For both the material and the non-material infrastructure, the slow time scale is essential. The durability of location attributes implies that the allocation of other more mobile production factors has sufficient time to adjust to persistent spatial differences (Johansson, 1998 a).

Johansson (1993 b) recognizes that the material infrastructure, with its associated networks, functions as a set of systems for economic interaction. He claims that the development of prototypes, the adaptation of novel products, and the routine processing of mature products each constitutes a distinct type of activity. Each such type has specific interaction characteristics and needs. Thus, each type demands particular combinations of infrastructure attributes from its regional economic milieu..

A network is an infrastructure, which facilitates interaction within and between regions. The interaction between intra-regional and inter-regional networks determines the long-term evolution of spatial economic systems (Johansson, 1993 b). Intra-regional networks make it possible for economic actors to benefit from the proximity of dense urban structures and to develop and restructure interpersonal networks. Such development and restructuring of links between economic partners and between buyers and sellers constitute the most basic mechanism for the evolution of every market. These link-shaping activities are almost exclusively hosted by urban environments with suitable infrastructure attributes (Johansson, 1989 a). They are investments in more or less durable links for communication and the exchange of information and knowledge, where the formation and maintenance of the links require personal face-to-face contacts. Frequent contacts require appropriate intra-regional and, in particular, urban infrastructure. Such infrastructure combines accessibility in local networks with a dense environment of meeting places and multi-purpose facilities. A productive urban economic milieu offers a variety of opportunities for personal contacts among people with diverse experiences, competences and skills (Johansson, 1993 b).

In a city with general and polyvalent characteristics, maturing activities often migrate to peripheral parts of the city region, while new activities benefit from a central location. Production that benefits disproportionately from a certain location can force out other activities by offering higher land rents. In this way, new and alert economic actors can use the same infrastructure over and over again. This implies that the market does not treat the infrastructure as a sunk cost. The urban infrastructure instead displays “hotel attributes” (Johansson, 1993 b).

3.2 Regional economic milieus and the economic specialization of regions

The dynamic processes that over time reshape a region’s economic milieu are driven on the one hand by external forces, and on the other hand by adjustment, development and investment processes within the region. The dynamics of these processes are often extended in time, due to the inertia associated with the transformation of regional resources. This inertia gives functional regions their identity and implies that their economic structure only changes gradually and at a slow pace.

The economic milieu of functional regions influences economic agents and their behavior in three ways:

- The production capabilities of regions differ between industries. This implies that a specific set of infrastructural location attributes influences the productivity and cost structure of firms in a non-uniform fashion. (Johansson, 1998 a).[4]
- The attractiveness of regions regarding different activities, for example the in- and out-migration of households and firms, and the expansion and contraction of firms (Johansson, 1998 a).[5]
- The innovative capabilities of regions, such as the creation of new knowledge, inventions, and innovations.

Regional scientists have employed two types of models to explain location patterns and regional specialization, which both can be extended to include dynamic change processes. The first type consists of models with a central place system. Central place models focus on demand-driven specialization, in the sense that regions that are large and dense can host a richer variety of output than smaller and sparser regions (Beckmann, 1958, 1996; Tinbergen, 1967). In such models, it is the size of the set-up costs for each product that determines the size a region's market area must have for a product. If the market area is too small, the region will not host the activity in question. At a given point in time, it is possible to identify products, which are only produced in those regions where the regional demand is large enough.

The location advantages offered by a region's economic milieu may also determine its specialization. Location advantages are relative characteristics of regions. It is only possible to

[4] In Johansson (1993 c), a quasi-dynamic model is applied to estimate how the economic milieu in municipalities influences the production in different manufacturing industries (See also, Johansson, et al., 1991; Johansson and Karlsson, 1994; Forslund and Johansson, 1995).

[5] The study by Holmberg & Johansson (1992) indicates, for example, that service sectors, such as wholesale, transportation, consulting and financial services are concentrated in municipalities in which the infrastructure facilitates interpersonal contacts and mobility.

evaluate a region by comparing the location advantages offered by different regions. Every functional region's profile of location advantages has its basis in the region's relative supply of resources. Lasting location advantages can only derive from resources that are immobile and change slowly. This builds on the assumption that it is possible to classify economic adjustment processes according to their speed (Johansson, 1985; Johansson and Karlsson, 1987). Johansson (1989 b) presents results from mathematical models of dynamic systems, with the aim of identifying the importance of separating processes that operate on significantly different time scales. The formation of a network infrastructure and network flows constitute, a slow and a fast process, respectively.

In the second type of model – location advantage models – the relative supply of trapped resources determine the specialization patterns of regions in a multi-regional system (Johansson and Karlsson, 1987; Johansson, 1997). The assumption of trapped resources has long been important for explaining regional specialization and trade within a Heckscher-Ohlin framework (Ohlin, 1933). Certain economic activities use natural resources, which producers have to extract or harvest within the region of production. A standard location advantage model will predict where, among available regions, such resource production will take place (Moroney and Walker, 1966; Smith, 1975). Location advantages are not limited to the spatial distribution of natural resources, but also include various localized (i.e. regionally trapped) non-land production factors, such as infrastructural and human capital. These resources are not as immobile as natural resources but their potential relocation ("speed of adjustment") is slow relative to other economic adjustment processes.

A starting point for analyzing how location advantages influence regional specialization is that at each point in time, the various types of trapped resources are unevenly distributed over functional regions. Moreover, certain trapped resources are highly concentrated in functional regions with specific characteristics, such as their positions in networks for communication and transportation. If we assume that the spatial density of certain trapped resources is changing at a much slower pace than technology, it is possible that a technological change induces a relocation of production and a corresponding change in interregional trade patterns. As a consequence, slowly adjusting resources govern the emergence of new patterns of regional specialization. The structural economic development in a system of functional regions is the outcome of various interlinked adjustment processes that operate at different time scales.

Both the central place and the location advantage approach stress the role of durable regional characteristics. Central place models focus on the accessibility to local and external markets, while location advantage models focus on durable trapped characteristics. Nevertheless, both these types of traditional models have limited explanatory power. If we assume durable regional characteristics as the only explanation of trade patterns, it becomes impossible to explain why regions that produce an almost identical set of goods trade with each other. The traditional approaches are also unable to explain how the behavior of economic agents may change the specialization of regions.

3.3 Spatial transaction costs and endogenous specialization

By combining assumptions about internal market potentials, increasing returns and spatial transaction costs, Johansson and Karlsson (2001) provide a framework for analyzing the endogenous specialization of functional regions. Both internal and external economies of scale can generate increasing returns. External economies of scale (i.e. agglomeration economies) consist of localization economies and urbanization economies. Localization economies are specialized external economies of scale, and are common in both large and small functional regions. An abundance of general positive supply externalities cause urbanization economies, and they are therefore associated with large urban regions (Vernon, 1960).

While large regions can specialize in diversity, Johansson and Karlsson (*ibid*.) argue that localization economies provide an opportunity for small and medium-sized functional regions to develop competitive specialization clusters, even though the internal market potential of such regions is much smaller than that of a large metropolis. They therefore elaborate on the role of internal and external scale economies in combination with product-specific spatial transaction costs in the economic development of small and medium-sized functional regions.

Spatial transaction costs comprise both transportation and general transaction costs, which vary with the geographical distance between seller and buyer, and the properties of each specific spatial interaction link. Using the two concepts of functional (urban) regions and spatial transaction costs as their starting point, Johansson and Karlsson employ the following assumptions in order to generate a framework for analyzing endogenous regional specialization:

1. The overall pattern of spatial transaction costs delimits functional regions. For contact-intensive transactions, the spatial transaction cost level is much higher across than within regions.
2. A region's population size and total purchasing power determines its internal market potential.
3. Internal and external markets make up the total market potential of a functional region. Networks for trade and other economic interactions connect each functional region to its external markets. The interaction intensity varies across such networks, and makes it

possible to identify a hierarchy of sequentially widening transaction areas for each region, so that transaction costs rise in a stepwise sequence.

4. A region's location of activities and specialization is a process, which is influenced by two basic conditions: technology and scale effects; and durable regional characteristics.

Using this framework, Johansson and Karlsson (*ibid.*) explain internal and external scale economies theoretically, by showing how these phenomena combine and interact to generate cumulative specialization processes in functional regions. In particular, they focus on the specialization of small and medium-sized regions. An insightful contribution is their development of the spatial transaction cost concept, which is essential for understanding both the specialization opportunities of regions of different sizes and scale-based specialization. In relatively small regions, they show that the development of localization economies is indispensable in the absence of natural resource endowments.

Combinations of three phenomena cause external scale effects: specialized labor markets, specialized neighborhood firms, and information spillovers. The first two phenomena give rise to intra-market effects, whereas information spillovers among firms are collective extra-market effects. They also illustrate how it is possible to order contact-intensive goods and services with respect to their dependence on the size of the internal market potential. Generally speaking, the flow intensity of long-distance inter-regional trade drops discontinuously at the borders of affinity-classified transaction areas, where such borders act as affinity barriers.

It is important to observe that spatial transaction costs do not remain constant over time. A general development path is the seemingly unlimited extension of markets until they become global. Two network phenomena explain this (Hacker *et al.*, 2004): The first phenomenon, which usually involves multinational corporations, is the development of economic links that allow transactions to be carried out over long distances at reduced cost. The second associated phenomenon is the development of networks for conveying information, services, goods, and people. The evolution of such networks reflects ambitions of making transactions less distance-sensitive (Andersson, 1986).

External economies play a key role in current explanations of location advantages and regional economic specialization. However, the literature is not always unambiguous in its use of this concept. Johansson (2005) suggests that it is possible to avoid such ambiguity by making three distinctions: the "source" of the externality (proximity versus network externalities); the economic nature of externalities (pecuniary versus non-pecuniary externalities); and the consequence of the externalities (efficiency versus development externalities).

3.4 Combining Resource-based and Scale-based Models of Regional Specialization

The discussion of regional specialization in the preceding sections has focused either on resource-based or scale-based specialization. However, Holmberg et al. (2003) show that it is possible to combine resource-based and scale-based assumptions into an integrated theoretical framework of endogenous regional specialization and growth. They do this for each sector in the regional economy by associating resource-based advantages with input-market potentials and scale-based advantages with customer-market potentials. Input-market and customer-market potentials tend to vary with the economic size of functional regions. This makes it possible to combine resource-based with scale-based regional specialization and growth processes.

Modern resource-based models emphasize the supply of knowledge-intensive labor as a primary specialization factor. Thus, Holmberg et al. (*ibid.*) focus on the interaction between population changes and the development of economic activity in functional regions, paying special attention to the knowledge intensity of the labor force. This includes labor location dynamics relating to housing and job opportunities as well as the supply of household services. A major concern is to combine two conflicting assumptions, which are that (i) people follow jobs and that (ii) jobs follow people.

Holmberg et al. (*ibid*.) assume the self-generating processes that change regional specialization over time to have the form of interdependent dynamic processes that involve economic activities and the population size. The literature contains a number of empirical models that emphasize the exact form of the dynamic interdependence (Mills and Carlino, 1989; Holmberg and Johansson, 1992; Johansson, 1996).

In this theoretical framework, the infrastructure for interaction functions like an arena that links resource-based and scale-based models of regional specialization. The market potential of a firm refers to its accessibility to customers and input suppliers, including suppliers of labor services. The infrastructure facilitates the development and growth of the market potential as well as its density[6]. The location factors for households include accessibility to jobs, household services, and amenities. Again, the same infrastructure helps to create accessibility and density. A basic idea in this approach is that not only physical infrastructure but also market potentials are slowly adjusting variables.

Holmberg et al. (2003) illustrate how a set of self-reinforcing processes contributes to the growth (decline) of the market potential of a region that is experiencing a process of endogenous

[6] A number of recent empirical studies illustrate the importance of "economic density" in functional regions (Ciccone & Hall, 1996; Johansson, 1996; Johansson, Strömquist & Åberg, 1998; Karlsson & Pettersson, 2005).

change. The development of firms interacts with the development of customer-market potential, input-market potential, and labor-input market potential. Households interact with job-market, housing-market, and consumption-market potentials. The input-market labor-input-market potentials are core variables in resource-based models of regional specialization and growth. The customer-market potential refers to the opportunities of firms to benefit from both internal and external scale economies. The job-market potential is a measure of the friction households with a given location face when they search for jobs with acceptable commuting conditions. A combination of large job-market and housing-market potentials increases a household's opportunities of finding an efficient match between its job and housing locations. The size of the consumption-market potential determines the opportunities for households to benefit from variety in consumption.

What can these self-reinforcing processes look like? We can imagine a functional region whose market potential has increased due to improvements in the transportation infrastructure. This will stimulate firms with internal scale economies to locate in the region and existing firms to expand their activities. In-migration of firms to the region and expansion of the region's native firms will increase the market potential of the region, generating further in-migration and expansion. As production grows, the cost per unit of output falls, due to scale economies. This allows the price of interregional exports to fall, which stimulates growing export flows. In such a process, the external market potential grows as a share of the total market potential.

When firms with similar activities locate and expand in the region they generate external economies, which induce more firms in the same industry to locate and expand in the region. A growing demand for inputs stimulates input suppliers to locate and expand in the region as long as their deliveries are distance-sensitive, which in turn stimulates the in-migration and expansion of customer firms. A growing demand for inputs increases the opportunities of input suppliers to take advantage of their internal economies of scale but also to develop their own external economies. When the internal market potential expands this may induce falling output prices, which in turn further stimulates exports to other regions. In this way, the external market potential increases its impact on the cumulative growth trajectory. The demand from export markets may also by itself generate self-reinforcing growth (Johansson and Lööf, 2006).

What about the location of labor? The assumption here is that functional regions with attractive location characteristics for consumers attract households, especially households with a lot of human capital. A region's attractiveness depends on the infrastructure, which comprises the region's housing market and the accessibility from dwellings to the supply of household services, the supply of amenities of various kinds, and job opportunities (i.e. to household market potentials). This implies that regional labor markets must increasingly adjust through a process where firms follow the location of the supply of labor, rather than the opposite.

The location of households and jobs form a self-reinforcing dynamic process. The process is affected by the formation of regional infrastructure, which gradually improves or deteriorates, from the economic actors' points of view. Naturally, the job-location process partly shapes the economic milieu. However, the assumption is that the infrastructure changes at a much slower pace than the location of jobs. In the short run it is therefore possible to treat the infrastructural characteristics as approximately fixed. The same argument applies to the relation between location characteristics and the dynamics of household location. The overall regional change process is dynamic in that jobs and households mutually adjust to each other. This formulation is in sharp contrast to the well-known export-base model. According to that model, economic activities have fixed locations while the labor supply of households adjusts to the demand for labor through a process where households follow jobs.

3.5 Economic specialization in small and large regions

When analyzing a functional region and its location advantages, it is useful to make a distinction between two dimensions as in Table 1. The table highlights the differences between large and small regions, and therefore their specialization opportunities. A region with a clear and narrow specialization is quite different from a region that has a diversified economy with many specializations. Smaller regions may rely on the availability of a particular natural resource, on economies of scale, or on localization economies, which are always combined with a limited intra-regional market potential. In small regions, the material and non-material infrastructures are less general and diversified than in a large regional economy (Johansson and Karlsson, 1990 a). According to Marshall (1920), localization economies derive from a pooled market for labor with specialized skills, the provision of non-traded inputs of a collective nature, and spillovers of entrepreneurial and technological knowledge, which can spread more easily in a local environment.

Localization economies may develop when firms with similar activities locate together, whereby they form a “cluster.” This implies that cluster formation is a cumulative process (Johansson, 2006). At each point in time, one may analyze a static cross-section of co-located industries and firms. It is common to interpret such location patterns as equilibrium outcomes. However, it is also possible to conceive of such a cross-section as a momentary image of a dynamic process, where an attractor drives the dynamics, and where this attractor may have (implicit) equilibrium properties.

A small region can specialize in the exploitation of natural resources (to the extent that they are available) and in the development of a limited number of industries serving distant markets. If it is successful in harnessing its location advantages, one or a few specialized clusters may emerge. Early phases of cluster development often build on notable innovative successes.

Table 1 The infrastructure of functional regions

	Demand conditions	Supply conditions
Intra-regional infrastructure	Intra-regional accessibility to • general customers • specialized customers • purchasing power	Intra-regional accessibility to • labor with varying skills • natural resources and amenities • housing and consumer services • producers in different industries • knowledge resources
Inter-regional infrastructure	Inter-regional accessibility to • general customers • specialized customers • purchasing power	Inter-regional accessibility to • suppliers • competitors • knowledge resources

Large and dynamic urban regions offer agglomeration economies which provide a creative milieu (Andersson, 1985), a diversified supply of producer services, a diverse supply of human capital, as well as intra-regional and inter-regional information flows. For the most part, large urban regions offer a more diverse supply of markets than smaller regions (Hacker et al., 2004). This reflects differences in geographic transaction costs among goods and services. Profit-seeking firms cannot supply distance-sensitive goods or services in functional regions where the demand is too small to cover fixed costs.

The theoretical background is as follows: Diversity in the set of regionally produced consumer goods or producer inputs can yield external scale economies, even if all individual competitors and firms earn normal profits. The size of a functional region in terms of aggregate purchasing power determines the number of specialized local consumer goods and producer inputs, given the degree of substitutability among the specialized local goods in consumption and among specialized inputs in production:

"A larger city will have a greater variety of consumer products and producer inputs. Since the greater variety adds to consumer well-being, it follows that larger cities are more productive, and the well-being of those living in cities increases with their size. This is true even when all firms in these cities earn a normal rate of profit." (Johansson and Quigley, 2004, 170)[7]

There are two well-known models, which deal with the advantages of a diversified urban economy. The first model focuses on urbanization economies in general such as consumers' taste for variety and, in addition, the productivity of specialized production factors. The second model is quite different: the proximity and linkages of firms in an agglomeration enhance their productivity. The perspective is here forward and backward linkages among economic agents such as firms.

Thus, large functional region have quite different specialization opportunities compared with smaller regions, since the demand for diversity and variety favors location of activities and households in large functional regions. Large home markets in conjunction with high accessibility to external markets enable many large urban regions to develop specializations (i.e. clusters) in many different industries. Firms in the same cluster may represent different stages in the production chain and also industries offering supplementary services.

In many large regions, services predominate. Because of their great market potential, large regions make it possible also for firms with a "thin" but distance-sensitive demand to find

[7] However, there are factors, which limit the growth of cities. Otherwise, cities would grow continuously. There are costs which rise with city size, most obviously prices (space in particular), and some external costs like congestion and pollution. Also probably, crime rises with city size.

sufficient demand to earn a profit, even with substantial fixed costs. Large urban regions are especially attractive to such firms, which imply that one important characteristic of large urban regions, besides hosting many clusters in different industries, is the diversity of goods and services offered to consumers as well as to other firms.

Another characteristic of large urban regions is that they host great concentrations of knowledge in the form of human capital, both in the form of labor and infrastructural facilities such as universities. Head offices of multinational corporations are nearly always in the downtown areas of major cities, and so are often their research and development divisions. Large regions are almost always well connected to the global air transportation network and – in Europe and Japan – to high-speed rail networks. Their access to global transportation networks makes large cities attractive meeting places in which to stage conferences, trade fairs and the like. Taken together, these conditions imply that large cities often perform gateway functions, which means that they functions as import nodes for new ideas, inventions, and innovations, which are then disseminated to their low-accessibility hinterlands (Andersson and Andersson, 2000).

Most large urban regions have high per capita incomes, relative to smaller regions in the same part of the world. Their relative affluence implies a greater-than-average demand for income-elastic goods and services. Such regions also tend to host a number of firms that are demanding customers in their own right, such as hospitals and high-technology firms with a high demand for new advanced technology. There is consequently a large demand for new advanced products from both consumers and producers.

The demand for new advanced products in large urban regions has two implications. First, there is an especially great demand for imported products, since most new advanced products are first produced somewhere else. Second, most large regions offer good conditions for the development and introduction of new products since there is a spatial concentration of customers with a sufficient willingness to pay.

We see a general pattern emerging. The larger the region is, the better are the conditions for innovation. And the better the conditions for innovation are, the more dynamic the region becomes. Of course, large urban regions are not *equally* dynamic, but there is nonetheless a strong tendency for the largest regions to be the most dynamic in a global sense. The names of the most successful dynamic regions are well known in both the scholarly and popular literature, and they coincide with those functional urban regions that have the greatest aggregate purchasing power.

Many of these large urban regions have been dynamic and innovative for a long time. Still, historically there are plenty of examples of urban regions, which have lost much of their creative potential. One colorful description of how a dynamic region lost much of its innovative power can be found in Jacobs (1969), where she describes the fate of Manchester, which for a long time was the world's leading innovative milieu in the textile industry. An interesting aspect of Jacobs' analysis is that she contrasts Manchester with Birmingham, where Birmingham fared better because it was less dependent on (standardization-prone) large-scale manufacturing.

We will not discuss any more examples of large urban regions, which over time seem to have become less dynamic. Instead, we turn to the problem of keeping regions innovative.

4. Regional Dynamics

The international economic system contains large metropolitan regions, which serve as spatial focal points (Johansson and Karlsson, 1990 b). In small countries, it is common for a single urban region to develop into the only international gateway. In other cases, several large regions share the role of being gateways to a system of functional regions. Gateways specialize in importing recent ideas, inventions, and innovations. Besides being “sinks” for novel inputs from the world economy, gateways function as incubators for new products. Imports are important stimuli for product innovation. On the one hand, they may stimulate direct imitation. More importantly, imports may induce the product innovation, both in the form of incremental adaptations of the design and new complements. Given their dual nature as “sinks” and incubators, gateways are normally the most dynamic regions in each country.

All gateways coordinate spatial customer networks, which link a set of peripheral nodes to the central gateway node. Peripheral nodes usually specialize in production for export. They receive information about new ideas and trends from the central gateway node. Export nodes sometimes have strong linkages to several more central nodes, including nodes in other countries. Multinational corporations are especially notable as facilitators of such international links

Not all large urban regions are gateways, and some gateways have medium-sized populations. For example, one group of large regions specializes in large-scale industrial production for long-distance export. If we take a snapshot of a country and its system of functional urban regions, we can observe how the different regions have acquired specialized roles in the national and global economy by pursuing different development paths. The development path of an individual region is the result of a dynamic interplay between internal and external forces. Different paths additionally have path-dependent risks and uncertainties, since some -- but not other -- regional specializations may become technologically obsolete or uncompetitive due to new low-cost competitors in other parts of the world. At the same time, accumulated investments in specialized skills, capital, and institutions may create rigidities which make necessary restructuring both slow and difficult (Johansson and Karlsson, 1990 a).

To understand how the regional specializations and patterns of interaction change over time, it is necessary to adopt a time scale that is long enough to accommodate cyclical changes in production patterns. The production of most goods and services evolves through a cyclical pattern where an initial expansion yields to standardization and, in the long run, obsolescence. In the production of standardized goods, only those firms survive that manage to cut production costs, either through relocation to regions with cost advantages or through process innovation. In the long run, however, it is only through the substitution of new goods for obsolete ones that the relative wealth of a region can endure (Johansson and Karlsson, 1990 b). Economic development depends on the pace and coordination of such renewal processes. In successful cases, the expansive phase gives rise to product and process innovations that cause temporary monopoly profits. Successful innovations not only cause temporary profits but also give rise to long-term productivity and employment gains. Regions without natural resource advantages must develop knowledge advantages to achieve high living standards.

In order to observe the product life cycle it is necessary to devise a method that can distinguish between different products in such a way that each product has a definite market entry (birth) and market exit (death), to the extent that the latter occurs (Batten and Johansson, 1989). With such a method, it also becomes possible to superimpose individual life cycles that result in aggregated cycles, which describe long-term economic waves and their associated spatial relocation waves. Such aggregation generates an image of long waves for entire product groups and technological families. The importance of this observation becomes significant when we note that during recent centuries it is possible to distinguish periods with identifiable technological shifts. Each such period of restructuring has intensified the initiation of new product cycles.

What are then conditions for successful innovation, leading to a take-off and expansion of production as well as the initiation of a new product cycle? The simple answer is that production must be profitable enough to redirect resources from existing production, within the region and sometimes from other regions. This implies that entrepreneurs bid up the prices for land and labor.

When the prices of production factors increase, firms that produce mature products discover that they suffer losses even if they introduce process innovations. Before long, they face the choice between terminating and relocating production. Whatever they decide, the result is that resources become available for newer products. Recurrent structural change is a precondition for a region's long-term viability.

Even if higher wages induce a flow of labor to the innovative regions, the termination or relocation of older production is necessary in order to release land to the new, higher-valued, and thus more efficient use. In addition, improvements to the physical infrastructure make an increased density possible and leads to greater overall accessibility.

The key point in this section is the importance of the out-migration of mature products from dynamic, innovative regions for the development of both innovative and imitating regions in a multi-regional system. In the next section, we will present two theories, which both offer dynamic explanations of the location behavior of firms in a system of functional urban regions.

4.1 Location Dynamics in a System of Functional Urban Regions

The filtering-down theory and the spatial product cycle theory provide alternatives to the neo-classical convergence theories. They both offer dynamic explanations of the location behavior of firms in a system of functional urban regions, employing -- in the first case -- a central place system or -- in the second case -- the concept of location advantage. Both theories assume that the development of a product or an industry follows a sequence with an introduction, a growth, and a maturation phase, that takes the form of an S-shaped growth curve. The life-cycle perspective makes it possible to see patterns in the continuously adjusting spatial structure of both intra-regional and inter-regional development. In particular, the life-cycle concept seems to be a useful device for explaining location dynamics, especially in the case of inter-regional relocation processes for new products and industries (Aydalot, 1984).[8] However, we should note that some activities do not exhibit cyclical behavior. These activities are mainly non-standardizable activities such as customized delivery of goods and services, where each delivery has new and individual attributes (Forslund, 1997).

Even if there are many similarities between the two theories there is also one major difference: while the filtering-down theory stresses that products and industries filter down through the system of functional urban regions in a hierarchical manner from regions with larger market areas to regions with smaller market areas (Thompson, 1969; Moriarty, 1991), the spatial product cycle theory does not present any similar strict hypothesis concerning the spatial diffusion and relocation pattern as products age (Karlsson, 1988).

Both theories distinguish between the development of new (young) products and the production of mature standardized products with routine production. Both theories further assume that a high proportion of all new products are initiated or imitated (at an early stage) in the leading functional urban regions, with opportunity-rich economic milieus and with substantial concentrations of knowledge resources (Johansson et al., 2006). Non-standard goods and services comprise customized deliveries as well as young products. Firms with such products find it advantageous to locate in large urban regions with good accessibility to diverse customer

[8] The continual self-reorganising and evolution of the global spatial economy at a macro scale can also be analysed by applyinng the ”new economic geography approach” (Fujita & Mori, 1998).

segments, R&D resources, and other suppliers of knowledge services. Other desirable location characteristics include a high purchasing power and good contact opportunities.

When a product and its market mature, it often becomes possible to standardize its design and automate its production process. At this stage, its production depends less on metropolitan market, making production in other regions possible. If a relocation or diffusion of production takes places, it can take many different forms (Johansson and Karlsson, 2003). Firms may relocate part or all of their production to other regions, but they may also outsource part or all of their production to one or several firms located in such other regions. Firms with production units in several regions may change its inter-regional division of labor. Chain-type firms may gradually expand production in different regions or franchise their business concept. In addition, firms in smaller regions may imitate products developed in large urban regions.

According to the filtering-down theory, technical and demand changes induce firms to shift the location of the production of existing products (or product groups) over time, thereby transforming the specialization pattern of regions (Camagni et al., 1986). This makes the filtering-down process both market-driven and technology-driven. On the one hand, standardization of products and production may lower both the set-up costs and variable production costs. On the other hand, demand may increase due to increasing real incomes, changing preferences, and outsourcing of activities from firms and households. Consequently, the production of different products may gradually filter down or diffuse downwards in the hierarchy of functional urban regions. In this way, the filtering-down theory refers to products that spread from one level of the hierarchy to all functional regions at the next lower level. If we consider a new product with high spatial transaction costs that has been introduced in the largest region in an economy, it will start to filter down the system of functional urban regions when the real income and hence demand increases in smaller regions or when the set-up costs for production has decreased sufficiently. This process stops at some level in the hierarchy of urban regions, if it is inconceivable to mobilize enough demand to make production profitable.

The spatial product cycle theory similarly assumes a relocation of production from the leading urban regions. However, the number of followers is limited, since economies of scale normally prevent decentralization to many regions, except in cases with very high spatial transaction costs. Changes in location are dependent on location advantages, even at later stages of the product cycle (Vernon, 1960; Hirsch, 1967; Andersson and Johansson, 1984 a). Hence, this theory stresses the importance of external economies for the location of production. When relocation does take place, it is limited to a small set of specialized regions. Localization economies are decisive and provide individual regions with their most important location advantages (Marshall, 1920; Krugman, 1991).

Andersson and Johansson (1984 a; 1984 b) use microeconomic models to show how product cycle assumptions generate location and relocation processes (see also Johansson and Karlsson, 1986; 1987). Both papers demonstrate how clusters of product cycles can be observed empirically in the form of aggregate specialization patterns, which describe a time-space hierarchy. In a later contribution, the two authors reformulate their results into a more coherent framework and emphasize new directions for this type of model formulations (Johansson and Andersson, 1998). In their later model, knowledge intensity, product standardization, and process routinization are key notions. Along a product cycle path, Johansson and Andersson assume that the knowledge intensity is high when a product is non-standardized and the production process is non-routinized. Standardization and routinization imply reduced knowledge intensity. Andersson and Johansson proceed to present a class of models that explains this regularity. They then derive interdependencies between location dynamics and product cycles that incorporate elements from models of monopolistic competition. Moreover, they use notions of product and process vintages to classify structural properties and the associated markets.

Products with relocated production usually have low spatial transaction costs and in this case production may be relocated for defensive as well as offensive reasons. The occurrence of new locations indicates that the product is no longer new, but the production process may continue to be renewed (Johansson, 1998 b). When the product is in its growth phase it may be too expansive to expand production in large urban regions and thus new locations are sought for the organization of large-scale production. Since the scale of production increases, there are strong preferences for locations offering good accessibility in the national and international logistical systems. At later stages of the product cycle, cost considerations become more important and production relocates to more peripheral regions or to regions abroad. Comparative advantages in the case of the spatial product cycle are often in regions that have lower land and property prices as well as lower costs of unskilled labor inputs (Andersson and Johansson, 1984 a, and b); Johansson and Strömquist, 1986; Johansson, 1993 b).

4.2 Lead-lag models

Johansson (1993 b) emphasizes the dynamics of product vintages as the force that drives the behavior of filtering-down and spatial product cycle models – an assumption that forms the foundation for empirical lead-lag models[9] (see also, Forslund and Johansson, 1995; Forslund, 1996; 1997; Johansson and Karlsson, 2003). The lead-lag model has the specific objective of generating hypotheses, which can be tested empirically. It classifies economic activities in such a

[9] The “flying geese model” proposed by for example Fujita and Mori (1998) can be considered as a special case of the more general lead-lag model.

way that it is possible to refer to them as clusters of products with synchronized location dynamics.[10] For a given system of functional urban regions, the model specifies -- for each type of product group (industry) -- its average share of all product groups (industries) in the system of functional regions (measured as employment or value added). The model identifies a specific leading region, for a given system of functional regions. The relative industry shares for the leading region are predictive indicators.

The basic hypotheses in lead-lag models are associated with the location leadership of the leading region. The first hypothesis states that product groups (industries) with high relative shares in the leading region should be expected to grow in other regions in the system of functional regions. The second hypothesis states that product groups (industries) with low relative shares in the leading region should be expected to decline in other regions in the system of functional regions. The first hypothesis implies that new product groups (industries) originate in the leading region. The second hypothesis implies that leading regions lose employment in mature product groups (industries) before other regions. Hence, they are leading regions also as regards the decline of products.

The above basic hypotheses yield a number of sub-hypotheses. For example, industries with both high relative shares and fast growth rates in the leading region are non-routinized activities and have non-standardized products that compete on the basis of product rather than price. They also tend to involve research and other knowledge production. Industries with low relative shares are on the other hand routinized activities that compete on the basis of price that aim at reducing the labor input coefficient.

[10] The lead-lag model does not apply to activities, which have to be harvested in the region where they are located. The location of such production is analysed by standard location advantage models, where the comparative advantages are of Ricardo type.

Lead-lag models assume that a high proportion of new products are initiated or imitated (at an early stage) in the leading region in the system of functional regions. As the production expands, products are frequently standardized and production techniques routinized, which is referred to as product vintage dynamics. As new product vintages are introduced, the pertinent activities are relocated or diffused within the system of functional regions. Analyzing vintage process dynamics as the driving force in spatial product-cycle and filtering-down models, it is possible to show that a gradual change in location takes place. The follower regions host industries for which the vintage renewal is dominated by standardization and routinization (Forslund and Johansson, 1998).

The main point we want to stress here is that the economy of nations and regions is rejuvenated when production from large urban regions relocates to successively smaller regions. Of course, the establishment of new production in these regions will also generate structural change. The new production units will tend to bid up prices for land and labor in these regions, thereby making the previous marginal production activities unprofitable. To the extent that labor relocates to large regions when new product cycles emerge, the structural changes in medium-sized and smaller regions may be even more pronounced.

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